

Research on Viral Hemorrhagic Septicemia at the Western Fisheries Research Center



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Background: Viral hemorrhagic septicemia virus (VHS) is considered by many nations and international organizations to be one of the most important viral diseases of finfish. For several decades following its initial characterization in the 1950s, VHSV was thought to be limited to Europe where it was regarded as an endemic pathogen of freshwater fish that was especially problematic for farmed rainbow trout, an introduced species. Because of the severe impact of VHS on farmed trout, the disease was among the first to be listed as reportable by the World Organization for Animal Health, of which the US and Canada are members. Beginning in the late 1980s, it was shown that VHSV was widely distributed among many species of marine and anadromous fishes in both the North Pacific and North Atlantic Oceans where it has been associated with substantial mortality among both wild and cultured fish.

In 2005, reports from the Great Lakes region indicated that VHSV had been isolated from fish that had experienced very large die-offs in the wild. By 2009, VHSV has been isolated from more than 25 species of wild fish in Lake Michigan, Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario, the Niagara and Saint Lawrence Rivers and from inland lakes in New York, Michigan, Wisconsin and Ohio. The Great Lakes strain of VHSV appears to have an exceptionally broad host range and significant mortality has occurred in some stocks of muskellunge, freshwater drum, yellow perch, round goby, emerald shiners and gizzard shad. Because of the emergence of VHSV in the Great Lakes region of the US and Canada, surveillance activities have increased in the region and new legislation has been implemented by Federal, State and Provincial management agencies. Some of the legislation has had significant economic impact on commercial fishermen and baitfish dealers as well as disrupting management efforts to restore important native fish or to stock fish for recreational activities.

Work at the Western Fisheries Research Center: The Western Fisheries Research Center (WFRC) in Seattle, Washington has an established history of research on important pathogens of finfish including viral hemorrhagic septicemia virus following its emergence in 1988 among marine and anadromous species on the west coast of North America. Immediately after the discovery of VHSV in the Great Lakes, the WFRC began to conduct research on the virus using redirected internal funds. This work included: providing immediate technical assistance and information to federal, state and tribal agencies as well as to the private sector; conducting a series of interviews with various media outlets, providing reference laboratory services for VHSV (sending cell lines, PCR primers, control materials) to various laboratories involved in increased surveillance activities; attending workshops hosted by the US Fish and Wildlife Service (USFWS) and US Department of Agriculture Animal, Plant Health Inspection Service (USDA-APHIS) to give background information and to lead research planning efforts; conducting sequence analysis of VHSV isolates to gain rapid epidemiological insights, testing cell lines and polymerase chain reaction (PCR) assays to ensure diagnostic procedures were optimal for the new strain of virus; providing regular advice and consultation to staff at USDA-APHIS, USFWS and various state agencies; and performing several laboratory experiments (fish challenges for species susceptibility, inactivation trials with various compounds and environmental conditions) at the request of federal and state fisheries managers.

Highlights and Key Findings:

1. The USGS laboratory in Seattle represents an internationally recognized center of expertise for research on VHSV. The WFRC is the sole international reference laboratory for two diseases of finfish specified by the World Organization for Animal Health (O.I.E.) in Paris, France. The WFRC is serving as a VHS reference laboratory for several federal and state agencies in close collaboration with the US Department of Agriculture.

2. Following the discovery of VHSV in the Great Lakes, the WFRC was able to provide immediate and critical advice or information to management agencies in the US and Canada. These agencies included national (e.g. US Department of Agriculture, US Fish and Wildlife Service, Department of Fisheries and Oceans Canada, Canadian Food Inspection Agency), State (e.g. Minnesota, Michigan, Wisconsin, Ohio, Illinois, Indiana, Pennsylvania and New York), Provincial (Ontario, Quebec), and Regional (Great Lakes Fish Health Committee, Pacific Northwest Fish Health Protection Committee) entities. The WFRC also conducted research to address emergency management needs to provide reference materials, validate assays, assess species susceptibility, and test virus inactivation methods.

3. The WFRC has developed an Integrated Research Plan for VHSV to be used by funding agencies to ensure efficiency, lack of duplication and proper sequencing of the national research efforts for VHSV. This plan has been used by national (USDA-APHIS, USDA-ARS) and regional (USDA Regional Aquaculture Centers) funding agencies to inform funding priorities. The WFRC has made significant efforts in this regard to avoid duplication of effort and waste of valuable resources.

4. The research at the WFRC has led to key insights about VHSV in the Great Lakes that include:

- All Great Lakes VHSV isolates (2003-2008) analyzed to date (more than 80) are within a few nucleotides of each other within the 669 nt region analyzed
- The very low diversity among the isolates suggests a recent, probably single, introduction via migratory species, baitfish, intentional movement of fish, or ballast water
- The isolates from the Great Lakes are most like isolates from the Atlantic coast of North America - but not identical
- The 2005-2008 VHSV outbreaks in the Great Lakes can be considered as one, large, multi-year, epizootic involving many species of fish in several connected lakes and rivers. Such outbreaks are not atypical among naïve populations following initial exposure to an introduced pathogen

5. The research at the WFRC has led to some predictions based on what we know from VHS in Europe and the west coast of North America, as well as from fish diseases caused by other rhabdoviruses such as IHNV, HIRRV and SVCV. These include:

- The virus is transmitted principally via waterborne exposure
- High levels of virus are shed by diseased fish and at spawning
- Virus will persist for much of the year in a small percentage of normal-appearing, low-level carriers
- Outbreaks will show a pronounced seasonality- esp. late spring

- There will be large differences in susceptibility among species
- The disease will be acute in the most susceptible species
- Disease will have population-level effects for some species
- The virus will be cleared from most survivors of infection
- Survivors will be immune to re-infection for several years
- VHSV will become more widely established in the GL Basin
- The virus can adapt to infect species formerly shown resistant
- The isolates will become more genetically diverse over time
- The virus will eventually have a very large host range
- Stressors will exacerbate latent infections and disease
- Disease will move toward younger age classes as an increasing percentage of recovered fish become immune
- Disease will become less explosive in most years
- The virus will spread to other freshwater systems in the US or Canada and to portions of the commercial aquaculture industry
- Disease will impact both management and commercial activities

6. Currently, VHS in North America affects free-ranging marine fish on the Pacific and Atlantic coasts and freshwater fish in the Great Lakes so present control approaches rely upon:

- Increased surveillance efforts by Federal, State and Provincial agencies to better define the current host and geographic range
- Improved knowledge of the potential host range
- Development of improved detection methods
- Federal, State and Provincial policies requiring VHSV-free certification for all live, susceptible species to be moved outside (or even within) the Great Lakes region

7. To avoid translocation of VHSV via recreational boats and ballasted ships, educational campaigns and more appropriate disinfection technologies are needed

8. To prevent or reduce the potential impact of VHS on public or private aquaculture, research is needed to:

- Improve biosecurity at fish rearing facilities (egg disinfection and water treatment technologies)
- Develop novel treatment methods including anti-viral drugs and chemicals
- Optimize existing and develop new vaccines and delivery systems
 - Killed vaccines with improved adjuvants
 - Test existing DNA vaccines and modify if needed

9. Because we do not understand the epidemiology of VHS, research is needed to:

- Test susceptibility of key species
- Determine effect of size or age on mortality and immunity
- Determine the nature and duration of immune response
- Understand the nature of the carrier state
- Investigate virus shedding during outbreaks and by carriers
- Study effects of environmental variables (e.g. temperature) on disease process
- Study effects of anthropogenic stressors (e.g. contaminants) on disease process

- Determine the genetic basis of virulence and host range
- Track genetic diversity of VHSV

Work Planned for FY10 at the Western Fisheries Research Center

1. Continue to provide a high level of technical assistance and advice to federal and state management agencies.
2. Perform contracted work for external funding agencies
3. Complete development of web-based VHS database for use by scientists and managers
4. Continue epidemiological analysis of new isolates provided by federal and state laboratories
5. Use the new yellow perch challenge model and the unique Biosafety Level 3 facility to
 - Initiate studies to determine the important role of temperature on the disease process
 - Determine the nature and duration of the immune response
 - Understand the nature of the carrier state
 - Investigate virus shedding during outbreaks and by carriers

This research is being coordinated with a broad range of federal, state and university scientists to ensure collaboration and lack of duplication.

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